Tubing Data

Contents

Tubing Selection

Proper selection, handling, and installation of tubing, when combined with proper selection of Swagelok® tube fittings, are essential to reliable tubing systems.

The following variables should be considered when ordering tubing for use with Swagelok tube fittings:

- Surface finish
- Material
- Hardness
- Wall thickness.

Tubing Surface Finish

Many ASTM specifications cover the above requirements, but they often are not very detailed on surface finish. For example, ASTM A450, a general tubing specification, reads:

> 11. Straightness and Finish
>
> 11.1 Finished tubes shall be reasonably straight and have smooth ends free of burrs. They shall have a workmanlike finish. Surface imperfections (Note) may be removed by grinding, provided that a smooth curved surface is maintained, and the wall thickness is not decreased to less than that permitted by this or the product specification. The outside diameter at the point of grinding may be reduced by the amount so removed.
>
> **Note:** An imperfection is any discontinuity or irregularity found in the tube.

Tubing Material

Our suggested ordering instructions for each type of tubing are shown under the respective tables.

Tubing Outside Diameter Hardness

The key to selecting proper tubing for use with metal Swagelok tube fittings is that the tubing must be softer than the fitting material. Swagelok tube fittings are designed to work properly with the tubing that is suggested in the ordering instructions.

Swagelok stainless steel tube fittings have been repeatedly tested successfully with tubing with hardness up to 200 HV and 90 HRB.

Tubing Wall Thickness

The accompanying tables show working pressure ratings of tubing in a wide range of wall thicknesses. Except as noted, allowable pressure ratings are calculated from *S* values as specified by ASME B31.3, Process Piping.

Swagelok tube fittings have been repeatedly tested in both the minimum and maximum wall thicknesses shown.

Swagelok tube fittings are not recommended for tube wall thicknesses outside the ranges shown in the accompanying tables for each size.

Tubing Handling

Good handling practices can greatly reduce scratches on tubing and protect the good surface finish that reliable tube manufacturers supply.

- Tubing should never be dragged out of a tubing rack or across a rough surface.
- Tube cutters or hacksaws should be sharp. Do not take deep cuts with each turn of the cutter or stroke of the saw.
- Tube ends should be deburred. This helps to ensure that the tubing will go all the way through the ferrules without damaging the ferrule sealing edge.

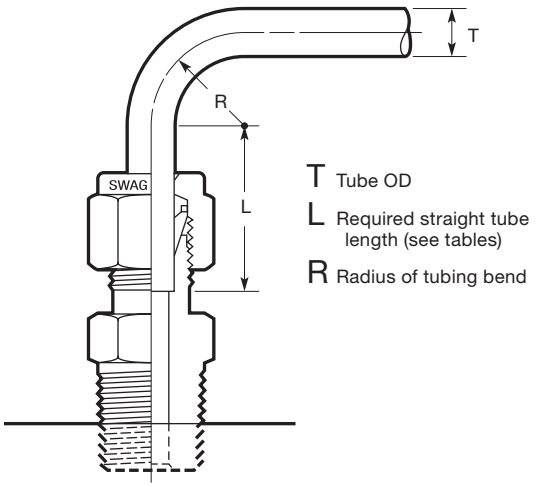
Gas Service

Gases (air, hydrogen, helium, nitrogen, etc.) have very small molecules that can escape through even the most minute leak path. Some surface defects on the tubing can provide such a leak path. As tube outside diameter (OD) increases, so does the likelihood of a scratch or other surface defect interfering with proper sealing.

The most successful connection for gas service will occur if all installation instructions are carefully followed and the heavier wall thicknesses of tubing on the accompanying tables are selected.

A heavy-wall tube resists ferrule action more than a thin-wall tube, allowing the ferrules to coin out minor surface imperfections. A thin-wall tube offers less resistance to ferrule action during installation, reducing the chance of coining out surface defects, such as scratches. Within the applicable suggested allowable working pressure table, select a tube wall thickness whose working pressure is *outside* of the shaded areas.

Tubing Installation



Tubing properly selected and handled, combined with properly installed Swagelok tube fittings, will give you a leak-tight system and provide reliable service in a wide variety of applications.

For maximum assurance of reliable performance, use:

- properly selected and handled high-quality tubing—such as provided by Swagelok
- Swagelok tube fittings assembled in accordance with catalog instructions
- an appropriate tube support system to limit the movement of tubing and fluid system components.

When installing fittings near tube bends, there must be a sufficient straight length of tubing to allow the tube to be bottomed in the Swagelok fitting (see tables).

Fractional, in.	
T Tube OD	**L**①
1/16	1/2
1/8	23/32
3/16	3/4
1/4	13/16
5/16	7/8
3/8	15/16
1/2	1 3/16
5/8	1 1/4
3/4	
7/8	1 5/16
1	1 1/2
1 1/4	2
1 1/2	2 13/32
2	3 1/4

① Required straight tube length.

Metric, mm	
T Tube OD	**L**①
3	19
6	21
8	23
10	25
12	31
14	32
15	
16	
18	
20	34
22	
25	40
28	46
30	50
32	54
38	63
50	80

Hydraulic Swaging Unit

A Swagelok multihead hydraulic swaging unit (MHSU) **must** be used to install 1 1/4, 1 1/2, and 2 in. and 28, 30, 32, 38, and 50 mm Swagelok tube fittings. For more information, see the *Gaugeable Tube Fittings and Adapter Fittings* catalog (MS-01-140).

Special Alloy Tubing

For sizes not listed in the following tables the Suggested Allowable Working Pressure is 500 psig (34.5 bar).

A limited amount of test data is available on Swagelok tube fittings used with special alloy tubing. For sizes not listed in the following tables, we recommend that a sample of the tubing be provided for evaluation before installation. Please include all pertinent information relating to system parameters. Give tubing sample to your authorized Swagelok representative to forward to the factory.

Suggested Allowable Pressure Tables

Figure and tables are for reference only. No implication is made that these values can be used for design work. Applicable codes and practices in industry should be considered. ASME Codes are the successor to and replacement of ASA Piping Codes.

- All pressures are calculated from equations in ASME B31.3, Process Piping. See factors for calculating working pressures in accordance with ASME B31.1, Power Piping.
- Calculations are based on maximum OD and minimum wall thickness, except as noted in individual tables.

  Example: 1/2 in. OD × 0.035 in. wall stainless steel tubing purchased to ASTM A269:

  OD Tolerance ± 0.005 in. / Wall Thickness ± 10 %

  Calculations are based on 0.505 in. OD × 0.0315 in. wall tubing.
- No allowance is made for corrosion, erosion, welding or bending.

Suggested Allowable Working Pressure for *Carbon Steel Tubing*

Table 1—Fractional Carbon Steel Tubing

Allowable working pressures are calculated from an *S* value of 15 700 psi (108.2 MPa) for ASTM A179 tubing at –20 to 100°F (–28 to 37°C), as listed in ASME B31.3. For working pressure in accordance with ASME B31.1, multiply by 0.85.

Tube OD in.	Tube Wall Thickness, in.														Swagelok Fitting Series
	0.020	0.028	0.035	0.049	0.065	0.083	0.095	0.109	0.120	0.134	0.148	0.165	0.180	0.220	
	Working Pressure, psig **Note:** For gas service, select a tube wall thickness outside of the shaded area. (See **Gas Service,** page 2.)														
1/16	9700														100
1/8		8000	10 200												200
3/16		5100	6 600	9600											300
1/4		3700	4 800	7000	9600										400
5/16			3 700	5500	7500										500
3/8			3 100	4500	6200										600
1/2			2 300	3200	4500	5900									810
5/8			1 800	2600	3500	4600	5300								1010
3/4				2100	2900	3700	4300	5100							1210
7/8				1800	2400	3200	3700	4300							1410
1				1500	2100	2700	3200	3700	4100						1610
1 1/4					1600	2100	2500	2900	3200	3600	4000	4600	5000		2000
1 1/2						1800	2000	2400	2600	2900	3300	3700	4100	5100	2400
2							1500	1700	1900	2100	2400	2700	3000	3700	3200

Suggested Ordering Information

High-quality, soft annealed seamless carbon steel hydraulic tubing, ASTM A179 or equivalent. Hardness not to exceed 72 HRB or 130 HV. Tubing to be free of scratches, suitable for bending and flaring.

Suggested Allowable Working Pressure for *Stainless Steel Tubing*

Table 3—Fractional Stainless Steel Seamless Tubing

Allowable working pressures are calculated from an S value of 20 000 psi (137.8 MPa) for ASTM A269 tubing at –20 to 100°F (–28 to 37°C), as listed in ASME B31.3, except as noted.

For Welded Tubing

For welded and drawn tubing, a derating factor must be applied for weld integrity:

- for double-welded tubing, multiply working pressure by 0.85
- for single-welded tubing, multiply working pressure by 0.80.

Tube OD in.	Tube Wall Thickness, in.																Swagelok Fitting Series
	0.010	0.012	0.014	0.016	0.020	0.028	0.035	0.049	0.065	0.083	0.095	0.109	0.120	0.134	0.156	0.188	
	Working Pressure, psig **Note:** For gas service, select a tube wall thickness outside of the shaded area. (See **Gas Service,** page 2.)																
1/16	5600	6800	8100	9400	12 000												100
1/8						8500	10 900										200
3/16						5400	7 000	10 200									300
1/4						4000	5 100	7 500	10 200①								400
5/16							4 000	5 800	8 000								500
3/8							3 300	4 800	6 500	7500①②							600
1/2							2 600	3 700	5 100	6700							810
5/8								2 900	4 000	5200	6000						1010
3/4								2 400	3 300	4200	4900	5800					1210
7/8								2 000	2 800	3600	4200	4800					1410
1									2 400	3100	3600	4200	4700				1610
1 1/4										2400	2800	3300	3600	4100	4900		2000
1 1/2											2300	2700	3000	3400	4000	4900	2400
2												2000	2200	2500	2900	3600	3200

① For higher pressures, see the Swagelok *Medium-Pressure Fittings* catalog, MS-02-335, or the Swagelok *High-Pressure Fittings* catalog, MS-01-34.

② Rating based on repeated pressure testing of the Swagelok tube fitting with a 4:1 design factor based upon hydraulic fluid leakage.

Suggested Ordering Information

High-quality, fully annealed (Type 304, 304/304L, 316, 316/316L, 317, 317/317L, 321, 347) (seamless or welded and drawn) stainless steel hydraulic tubing, ASTM A269 and A213, or equivalent. Hardness not to exceed 90 HRB or 200 HV. Tubing to be free of scratches, suitable for bending and flaring. OD tolerances not to exceed ± 0.003 in. for 1/16 in. OD tubing.

Note: Certain austenitic stainless tubing has an allowable ovality tolerance double the OD tolerance and may not fit into Swagelok precision tube fittings. Dual-certified grades such as 304/304L, 316/316L, and 317/317L meet the minimum chemistry and the mechanical properties of both alloy grades.

Suggested Allowable Working Pressure for *Stainless Steel Tubing*

Table 4—Metric Stainless Steel Seamless Tubing

Allowable working pressures are calculated from an S value of 137.8 MPa (20 000 psi) for EN ISO 1127 tubing (D4, T4 tolerance for 3 to 12 mm; D4, T3 tolerance 14 to 50 mm), at –28 to 37°C (–20 to 100°F), as listed in ASME B31.3, except as noted.

For Welded Tubing

For welded and drawn tubing, a derating factor must be applied for weld integrity:

- for double-welded tubing, multiply working pressure by 0.85
- for single-welded tubing, multiply working pressure by 0.80.

Tube OD mm	Tube Wall Thickness, mm														Swagelok Fitting Series
	0.8	1.0	1.2	1.5	1.8	2.0	2.2	2.5	2.8	3.0	3.5	4.0	4.5	5.0	
	Working Pressure, bar **Note:** For gas service, select a tube wall thickness outside of the shaded area. (See **Gas Service,** page 2.)														
1	820①														1M0
2	660①														2M0
3	670														3M0
4	500	660													4M0
6	310	420	540	710											6M0
8		310	390	520											8M0
10		240	300	400	510	580									10M0
12		200	250	330	410	470									12M0
14		160	200	270	340	380	430								14M0
15		150	190	250	310	360	400								15M0
16			170	230	290	330	370	400①							16M0
18			150	200	260	290	320	370							18M0
20			140	180	230	260	290	330	380						20M0
22			140	160	200	230	260	300	340						22M0
25					180	200	230	260	290	320					25M0
28						180	200	230	260	280	330				28M0
30						170	180	210	240	260	310				30M0
32						160	170	200	220	240	290	330			32M0
38							140	160	190	200	240	270	310		38M0
50										150	180	210	240	270	50M0

① Rating based on repeated pressure testing of the Swagelok tube fitting with a 4:1 design factor based upon hydraulic fluid leakage.

Suggested Ordering Information

High-quality, fully annealed (Type 304, 304/304L, 316, 316/316L, 317, 317/317L, 321, 347) stainless steel tubing, EN ISO 1127 or equivalent. Hardness not to exceed 90 HRB or 200 HV. Tubing to be free of scratches, suitable for bending or flaring. OD tolerances not to exceed ± 0.076 mm for 3 mm OD tubing.

Note: Dual-certified grades such as 304/304L, 316/316L, and 317/317L meet the minimum chemistry and the mechanical properties of both alloy grades.

Pressure Ratings at Elevated Temperatures

Table 26—Elevated Temperature Factors

Temperature		Tubing Materials							
°F	°C	Aluminum	Copper	Carbon Steel①	304, 304/304L②	316, 316L②	317, 317/317L②	321③	347③
200	93	1.00	0.80	0.95	1.00	1.00	1.00	1.00	1.00
400	204	0.40	0.50	0.87①	0.93	0.96	0.96	0.96	0.96
600	315				0.82	0.85	0.85	0.85	0.85
800	426				0.76	0.79	0.79	0.79	0.79
1000	537				0.69	0.76	0.76	0.76	0.76

Temperature		Tubing Materials								
°F	°C	Alloy 400	Alloy 20③	Alloy C-276③	Alloy 600③	Ti	Alloy 2507	Alloy 825	Alloy 625	Alloy 6Mo
200	93	0.87	1.00	1.00	1.00	0.86	0.90	1.00	0.93	0.90
400	204	0.79	0.96	0.96	0.96	0.61	0.82④	0.90	0.85	0.74
600	315	0.79	0.85	0.85	0.85	0.45		0.84	0.79	0.67
800	426	0.75	0.79	0.79	0.79			0.81	0.75	
1000	537			0.76	0.35				0.73	

① Based on 375°F (190°C) max.

② Dual-certified grades such as 304/304L, 316/316L, and 317/317L meet the requirements for the lower maximum carbon content of the L grades and the higher minimum yield and tensile strength of the non-L grades.

③ Based on the lower derating factor for stainless steel, in accordance with ASME B31.3.

④ Use of 2507 super duplex stainless steel at temperatures above 482°F (250°C) causes microstructural changes that lead to embrittlement and loss of corrosion resistance. Derating factor at 482°F (250°C) is 0.81.

To determine allowable working pressure at elevated temperatures, multiply allowable working pressures from Tables 1 through 25 by a factor shown in Table 26.

Example: Type 316 stainless steel 1/2 in. OD × 0.035 in. wall at 1000°F

1. The allowable working pressure at –20 to 100°F (–28 to 37°C) is 2600 psig (Table 3, page 5).
2. The elevated temperature factor for 1000°F (537°C) is 0.76 (Table 26, above):

   2600 psig × 0.76 = 1976 psig

The allowable working pressure for 316 SS 1/2 in. OD × 0.035 in. wall tubing at 1000°F (537°C) is 1976 psig.